Epec 3724 Control Unit

Technical Document



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DOCUMENT VERSION HISTORY

Date	Notes
09.03.2016	Document updated according to hardware changes (12 kΩ GND → 10 kΩ GND in DI/PI, DI, PWM/DI/DO, DO_GND/DI and AUX OUT pins)
03.06.2015	Document updated
24.03.2014	Updated sections *AI/DI_Type064_2, AI/DI_Type064_3, FB/AI_Type065_1, Temperature and Voltage Monitoring*.
28.06.2013	First released version

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1 PREFACE

1.1 Use of Symbols

This manual uses the following symbols to point out important information or safety instructions:



The information icon indicates important information and issues to be noted for the reader.



The caution icon indicates very important information or a warning. If the advices are ignored, it can result in personal injury or damage to software or equipment.



The (electrical) warning icon indicates a hazard which could cause an electrical danger and/or a personal injury.



CE compatibility
This symbol indicates that the product described in this manual complies with the requirements set in the CE Standard.



WEEE symbol
This symbol indicates that the product must be sent to separate collection facilities for recovery and recycling when the end-user wishes to discard the product.



E17 Approval
This product is certified with normal automotive (E17) EMC (electromagnetic compatibility) standards.

1.2 Basic Skills Required

The user of this document must have basic knowledge of machine controlling, CAN communication, PLCopen programming according to IEC61131-1 and should have skills to use CODESYS 2.3 programming environment.

Please refer to CODESYS 2.3 manual for further information concerning the programming environment and required installations.

Please refer to CAN and CANopen documentation from CAN in Automation (CiA) for further information on communication issues.

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1.3 Safety Guidelines

The user of this documentation should follow general machine safety guidelines, directives and regulation appropriate to his/her country or market area.

A separate safety analysis is always recommended for the machine and its control system. The features of this product should be well documented in machine and control system documents so that the machine operator has the right information how to operate the machine correctly and safely.

This product is designed to be used only for machine controlling purposes. The manufacturer does not assume any responsibility for this product being fit for any particular application, unless otherwise expressly stated in writing by the manufacturer.

This product complies with those certifications and standards that are listed below. The manufacturer does not guarantee that this product complies any other certification, standard or test than listed below.

This product is not field serviceable, so it should not be opened at any situation.

External fuses should be installed for the product or the system power supply.

The system should be designed and constructed according to the Epec general mounting and cabling instruction document.

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1.4 Warranty

The manufacturer does not assume any responsibility for the products being fit for any particular purpose, unless otherwise expressly stated in writing by the manufacturer.

The manufacturer gives the warranty of twelve (12) months to the products and thereto related firmware from commissioning or eighteen (18) months from the date of delivery of the products which ever occurs first.

The manufacturer is during the warranty period responsible for defects in the products and thereto related firmware resulting from faults in material, design or workmanship. The manufacturer's only obligation under this warranty is to, at its sole discretion, either to replace the products and/or thereto related firmware or to repair the defective products. The manufacturer shall, at its sole option, repair the products at its manufactory in Seinäjoki, Finland.

The warranty does not cover any costs related to removing or fastening of devices related to the products. Neither does the warranty cover the expenses of sending devices to or from the manufacturer for repairs. The warranty does not cover possible expenses relating to travelling, accommodation, daily benefits, etc. of installers.

The warranty becomes null and void if the buyer and/or a third party alters the products or the firmware in any way or if they are not used in accordance with the Manufacturer's operating instructions.

All claims with respect to defects in the products shall be made to the manufacturer without delay and no later than on the seventh (7th) day after the defect has been or should have been discovered by the buyer. The manufacturer strives to reply to the claim in writing within two (2) weeks from the receipt of the claim. The buyer shall attach to the claim a possible error report or equivalent explanation of the grounds for the claim.

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The manufacturer gives no other warranties whatsoever for the products than the warranty set out in this section and thus the warranty given in this section sets forth the warranty given by the manufacturer in its entirety.

1.5 Limited Liability

The manufacturer shall under no circumstances be liable for loss of production, loss of profit, loss of use or any other consequential damages and/or indirect losses, whatever their cause may be. In case claims based on product liability are brought against the Manufacturer for which claims the manufacturer may be liable, the manufacturer's liability is limited to the extent normally covered under normal product liability insurances.

The buyer shall compensate the manufacturer to the extent that the manufacturer might be liable to pay damages as a result of claims based on product liability according to paragraph above.

1.6 Environmental Statement

The manufacturer uses ISO14001 environmental certified processes and materials to manufacture products. The manufacturer undertakes to arrange for the recycling and scrapping of the products that are returned to the manufacturer by the buyer and/or the products that are received by the Manufacturer in connection with maintenance services performed as a result of that repairing of the products is deemed by the manufacturer to be inappropriate.

The manufacturer will charge a scrapping fee from the buyer according to the manufacturer's price list in force from time to time. No scrapping fee will, however, be charged for products that are received by the manufacturer during the warranty period.

WEEE
This product complies with the European Community Directive 2012/19/EU on waste electrical and electronic equipment (WEEE) encouraging and setting specific criteria for the collection, handling and recycling of electric and electronic waste.

RoHS
This product complies with the European Community directive 2011/65/EU (RoHS) restricting hazardous substances such as quicksilver and lead in electrical and electronic equipment.

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2 PRODUCT OVERVIEW



Epec 3724 Control Unit is a compact and robust multifunction controller with 16-bit processor and high calculating power. Epec 3000 product platform is fully compatible to the existing Epec product portfolio. Some of the advances of the Epec 3724 Control Unit are listed below.

Multifunctional Efficiency

- A multifunction controller
  - 16/32 bit processor
  - high calculating power
- Can be used used in a CAN control unit system as a controller with different kinds of sensors and actuators, such as
  - proportional valves,
  - servo motors, and
  - electro-hydraulic components
- Provides control system solutions for both centralized and distributed intelligence systems
- Fully compatible with the existing Epec product portfolio

Mechanics & hardware

- Robust, light and leak proof aluminium cover has been widely tested against different chemicals and environmental conditions
- The shape of the casing works to protect the electronics inside against mechanical wear.
- Equipped with gold plated, heavy duty AMPSEAL connectors
- Each connector is color coded and mechanically keyed to fit only to the correct, corresponding place
- Made in Finland

Versatile I/O capabilities

- Total of 52 I/O pins
- Most pins have multipurpose features
- All I/O pins are equipped with a short-circuit protection

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Application programming

- Application downloading is possible through CAN bus
- Epec products are based on PLCopen and CANopen®, which make them easily scalable to meet requirements for both small and large machines
- Open I/O and communication interface, thus making it possible to connect
    - sensors,
    - actuators,
    - joysticks, and
    - other devices

  from other manufacturers to optimize the whole machine environment, both technically and ergonomically.
- Internal diagnostics which makes it possible to
    - detect e.g. overvoltage and overtemperature alarms and
    - program customized log applications

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3 TECHNICAL DATA

Processor	16/32 bit CPU, 100 MHz
Memory	Flash memory: total 1600 kbytes RAM memory: 1024 kbyte + 138 kbyte (112 kbyte for PLCopen application variables) Non-volatile memory: 8 kbyte PLCopen application size up to 768 kbyte
Power	Nominal supply voltage 12/24 VDC systems (8,5 ... 33 VDC) Idle power consumption 1,5 W (+24 VDC, no external load)
REF voltage outputs	+5 V, +12 V
Diagnostics	Supply voltage Unit temperature REF voltage monitoring
Protection functions	Overvoltage protection Short-circuit protection for outputs
Programming	CODESYS 2.3
Software installation	Download via CAN1
Protection class	IP67
Size / Outer dimensions	147 x 113 x 46 mm 5.787 x 4.448 x 1.811 in
Weight	0,70 kg 1.54 lbs
Case material	Aluminum
Operating temperature	-40... +85°C -40...+185°F
Storage temperature	-40... +85°C -40...+185°F

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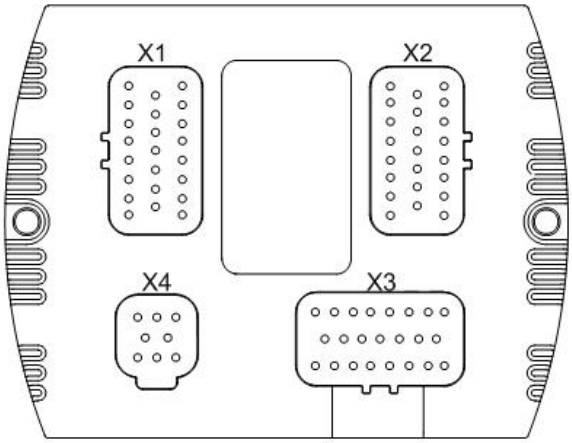
Connectors	3 x AMP23 1 x AMP8	
Communications/ Interfaces	2 x CAN 2.0B	
I/O pins total	52	
Outputs	24 x	PWM/DO/DI (sourcing, up to 3 A, PWM frequency by application)
	4 x	DI/DO (sinking)
Inputs	4 x	DI (pull-down to GND)
	4 x	FB/AI (current measuring feedback, 0-1 A)
	8 x	AI/DI (0-5 V / 0-22 mA selection by application)
	8 x	DI/PI (pull-down to GND)

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4 INPUT / OUTPUT SPECIFICATIONS

4.1 I/O List

The four connectors are placed in the control unit according to the following figure:



The following table lists the pins according their pin number. Other columns offer quick information about the pin and links for more information.

The group column:
* **smaller case characters** indicate the input groups (the pins in the same group have the same configurations)
UPPER CASE CHARACTERS indicate the output groups (the pins in the same group have the same configurations)

Connector 1:

Pin number	Pin type	Details	Group*	Current / Voltage	Description
First row:					
X1.1	PWM/DI/DO_Type051	10 kΩ GND	C	Nominal current 3 A	
X1.2	PWM/DI/DO_Type051	10 kΩ GND	J	Nominal current 3 A	
X1.3	PWM/DI/DO_Type051	10 kΩ GND	J	Nominal current 3 A	
X1.4	PWM/DI/DO_Type051	10 kΩ GND	J	Nominal current 3 A	
X1.5	FB/AI_Type065_1	0,22 Ω GND		0-1 A	
X1.6	FB/AI_Type065_1	0,22 Ω GND		0-1 A	
X1.7	PWM/DI/DO_Type051	10 kΩ GND	A	Nominal current 3 A	
X1.8	PWM/DI/DO_Type051	10 kΩ GND	A	Nominal current 3 A	
Second row:					
X1.9	GND				
X1.10	GND				
X1.11	GND				
X1.12	AI/DI_Type064_2	2,2 kΩ +5 V / 220 Ω GND		0-5 V / 0-22 mA	

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X1.13	AUX OUT (U = U_{in})	10 kΩ GND		max. 6 A	
X1.14	PWM/DI/DO_Type051	10 kΩ GND	A	Nominal current 3 A	
X1.15	PWM/DI/DO_Type051	10 kΩ GND	A	Nominal current 3 A	
Third row:					
X1.16	PWM/DI/DO_Type051	10 kΩ GND	B	Nominal current 3 A	
X1.17	PWM/DI/DO_Type051	10 kΩ GND	J	Nominal current 3 A	
X1.18	DO_GND/DI_Type048	10 kΩ GND		Nominal current 3 A	
X1.19	DI_Type046_4	10 kΩ GND			
X1.20	DI_Type046_4	10 kΩ GND			
X1.21	DO_GND/DI_Type048	10 kΩ GND			
X1.22	PWM/DI/DO_Type051	10 kΩ GND	J	Nominal current 3 A	
X1.23	PWM/DI/DO_Type051	10 kΩ GND	J	Nominal current 3 A	

Connector 2:

Pin number	Pin type	Details	Group*	Current / Voltage	Description
First row:					
X2.1	PWM/DI/DO_Type051	10 kΩ GND	J	Nominal current 3 A	
X2.2	PWM/DI/DO_Type051	10 kΩ GND	J	Nominal current 3 A	
X2.3	FB/AI_Type065_1	0,22 Ω GND		0-1 A	
X2.4	FB/AI_Type065_1	0,22 Ω GND		0-1 A	
X2.5	PWM/DI/DO_Type051	10 kΩ GND	G	Nominal current 3 A	
X2.6	PWM/DI/DO_Type051	10 kΩ GND	F	Nominal current 3 A	
X2.7	PWM/DI/DO_Type051	10 kΩ GND	E	Nominal current 3 A	
X2.8	PWM/DI/DO_Type051	10 kΩ GND	D	Nominal current 3 A	
Second row:					
X2.9	PWM/DI/DO_Type051	10 kΩ GND	H	Nominal current 3 A	
X2.10	PWM/DI/DO_Type051	10 kΩ GND	I	Nominal current 3 A	
X2.11	Logic Supply				
X2.12	AI/DI_Type064_2	2,2 kΩ +5 V / 220 Ω GND		0-5 V / 0-22 mA	
X2.13	GND				
X2.14	GND				
X2.15	GND				
Third row:					
X2.16	PWM/DI/DO_Type051	10 kΩ GND	A	Nominal current 3 A	
X2.17	PWM/DI/DO_Type051	10 kΩ GND	A	Nominal current 3 A	
X2.18	DO_GND/DI_Type048	10 kΩ GND			
X2.19	DI_Type046_4	10 kΩ GND			
X2.20	DI_Type046_4	10 kΩ GND			
X2.21	DO_GND/DI_Type048	10 kΩ GND			
X2.22	PWM/DI/DO_Type051	10 kΩ GND	A	Nominal current 3 A	

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X2.23	PWM/DI/DO_Type051	10 kΩ GND	A	Nominal current 3 A	

Connector 3:

Pin number	Pin type	Details	Group*	Current / Voltage	Description
First row:					
X3.1	REF +12V_Type070_1			+12 V 200 mA	Shared current with pin 3.9
X3.2	REF +5V_Type041_4			+5 V 270 mA	Shared current with pin 3.10
X3.3	GND				
X3.4	GND				
X3.5	AI/DI_Type064_3	82 kΩ GND / 220 Ω GND	a	0-5 V / 0-22 mA	
X3.6	AI/DI_Type064_3	82 kΩ GND / 220 Ω GND	a	0-5 V / 0-22 mA	
X3.7	AI/DI_Type064_3	82 kΩ GND / 220 Ω GND	a	0-5 V / 0-22 mA	
X3.8	AI/DI_Type064_3	82 kΩ GND / 220 Ω GND		0-5 V / 0-22 mA	
Second row:					
X3.9	REF +12V_Type070_1			+12 V 200 mA	Shared current with pin 3.1
X3.10	REF +5V_Type041_4			+5 V 270 mA	Shared current with pin 3.2
X3.11	GND				
X3.12	GND				
X3.13	AI/DI_Type064_3	82 kΩ GND / 220 Ω GND	b	0-5 V / 0-22 mA	
X3.14	AI/DI_Type064_3	82 kΩ GND / 220 Ω GND	b	0-5 V / 0-22 mA	
X3.15	LOADER BSL	For factory use only			
Third row:					
X3.16	DI/PI_Type046_3	10 kΩ GND			
X3.17	DI/PI_Type046_3	10 kΩ GND			
X3.18	DI/PI_Type046_3	10 kΩ GND			
X3.19	DI/PI_Type046_3	10 kΩ GND			
X3.20	DI/PI_Type046_3	10 kΩ GND			
X3.21	DI/PI_Type046_3	10 kΩ GND			
X3.22	DI/PI_Type046_3	10 kΩ GND			
X3.23	DI/PI_Type046_3	10 kΩ GND			

Connector 4:

Pin number	Pin type	Details	Group*	Current / Voltage	Description
X4.1	GND	Supply GND			
X4.2	CAN1 H				

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X4.3	CAN GND	Supply GND			
X4.4	Power Supply				
X4.5	Power Supply				
X4.6	CAN1 L (BSL)				
X4.7	CAN2 H				
X4.8	CAN2 L				

4.2 Configurable I/Os

Control unit contains inputs and outputs or, in other words, I/O pins of many different types. There are, for example, outputs which source current and outputs which sink current. Furthermore, there are I/O pins which can be used as inputs or as outputs at the control of the application programmer.

The following table contains a summary of configurable I/O pins in Epec 3724 control unit:

Max Amount	Pin Type	Info	DI	AI	FB	PI	DO		PWM
							PNP (sourcing)	NPN (sinking)	
24	PWM/DO/DI_Type051	3 A	x				x		x
4	DO_GND/DI_Type048	pull-down to GND						x	
8	DI/PI_Type046_3	pull-down to GND	x			x			
4	DI_Type046_4	pull-down to GND	x						
2	AI/DI_Type064_2	0-5 V / 0-22 mA	x	x					
6	AI/DI_Type064_3	0-5 V / 0-22 mA	x	x					
4	FB/AI_Type065_1	0-1 A			x				

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4.3 PWM/DI/DO_Type051

Output (PWM/DO)

- These pins are current sourcing outputs.
  - In other words, pin connects the load to positive supply voltage.
- The application program can also simultaneously monitor the actual state of the pin.
  - This feature makes it possible to detect short circuits to the ground and short circuits to the power supply.
  - Open loads can not be detected because the internal load resistor is connected to the ground.

- These kind of outputs are also capable to generate pulse width modulated (PWM) output signals.
  - This feature is useful when driving proportionally controlled loads, e.g. proportional hydraulic valves.

- PWM frequencies can be configured under software control in groups of outputs.
  - The setting is done by a PWM channel, setting the frequency of one channel sets also the frequencies of all the other channels in the same group.
  - The groups are indicated with upper case characters in the pin table's Group column in section *I/O List*).

- These outputs have integrated protection features (overload, overcurrent)
- This kind of pin can be used with a step motor (for more information refer to the Programming and Libraries manual)



If you want to use current measuring, connect the other end of the load to the feedback pin.



It is recommended to use the function blocks in *DigitalOutputDiagnostics* library to protect and diagnose outputs when used as digital outputs. For more information, refer to *Epec Programming and Libraries Manual*.

Input (DI)

- This pin can be used as a digital input (DI)
- A pin of this type can also be used as an input by using the output state monitoring feature.
  - In this case, the output functionality of the pin must be kept in the off state.



Closed circuit loops are mandatory when you are using DO or PWM pin as an input. Closed circuit loop means that the current from the control unit to the sensor must return to the same control unit, see the figures in section *I/O Cabling*.

Electrical characteristics

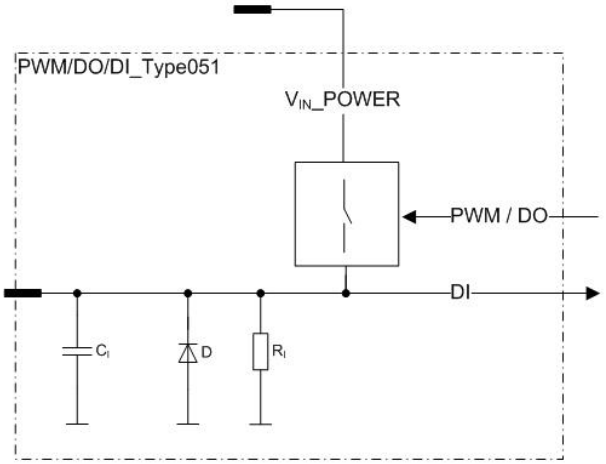
Symbol	Parameter	Conditions	Min	Max	Units
R_O	Output Resistance	Output On		0,2	Ω
I_O	Output Current	Output On	0	3	A
$I_{o\text{-}lim}$	Internal current	Output On (Note 2, 3)	typ. 12		A

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	limitation				
f_{PWM}	PWM Frequency	(Note 1)	10	3000	Hz
$Duty_{PWM}$	Duty Cycle	(Note 4, 9)	0 to 100,0		%
Res_{PWM}	PWM Resolution	(Note 1, 8)	0,1		%
Digital status input					
R_I	Input Resistance	Output Off; Referenced to GND	typ. 10		kΩ
V_{IH}	Input High Voltage	Output Off (Note 7)	3,5	U_{in}	V
V_{IL}	Input Low Voltage	Output Off	-0,5	1,5	V
f_I	Input frequency (digital input)	50% duty cycle (Note 4, 5)		1/ 2tC	Hz
t_I	Digital Status Input Pulse Width	(Note 5, 6)	> tC		ms
C_I	Input pin capacitance		typ. 1		nF

Note 1: PWM capable outputs are divided into groups. All outputs in the same group share the same PWM frequency (default value 10 Hz). The groups are indicated with upper case characters in the pin table's Group column in section *I/O List*.
Note 2: Current limit for short circuit protection to protect cabling and to limit internal power dissipation.
Note 3: When the limit is exceeded, the output voltage circuit starts to limit the current by switching the output voltage. The switching does not affect the application software.
Note 4: The duty cycle is defined as the percentage of digital 'high' to digital 'low' signals present during a PWM period.
Note 5: tC denotes the software cycle time.
Note 6: The pulse width must be greater that the software cycle time. For example with 50/50 pulse ratio, the pulse frequency is 1 / (2*pulse width)
Note 7: Exceeding the max value might cause permanent damage.
Note 8: The PWM resolution is defined as a maximum number of pulses that you can pack into a PWM period.
Note 9: When the frequency increases, the actual duty cycle may be bigger than the value that has been set.

Functional block diagram



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4.4 FB/AI_Type065_1

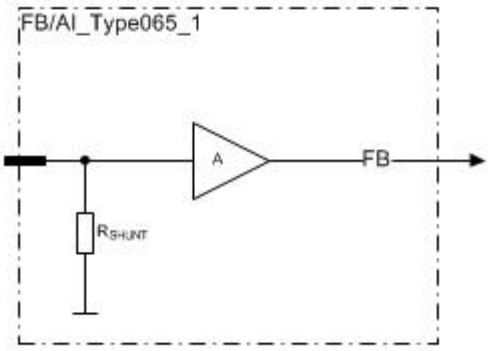
- These pins are normally used as a return path for the loads of PWM outputs (current measuring feedback)
- These kinds of pins have a small shunt resistor connected to ground
  - The shunt resistor is used to measure the current flowing through the load
- Nothing prevents using these pins to measure currents from other sources as well

Electrical characteristics

Symbol	Parameter	Conditions	Min	Max	Units
R_I	Input Resistance		0,21	0,23	Ω
I_I	Input Current	Analog measuring range	0	1,03	A
		(Note 1)		1,4	A
BW	Input Low Pass Filter Bandwidth	-3 dB cut-off frequency (Note 2)	typ. 27		Hz
I_E	Input Error	I_I = 1 A; Calculated		65	mA

Note 1: Exceeding the max value might cause damage to input.
Note 2: 2nd order low pass filter

Functional block diagram



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4.5 AI/DI_Type064_2

- These pins are analog inputs
- There is an internal 2,2 kΩ resistor connected to +5 V in the unit.
  - It provides appropriate measuring current for the external sensor. Any resistive sensor with reasonable resistance range can be used.

- The pins can be configured either as a current input or as a voltage input.
- There is a control signal for selecting:
  - Voltage mode: High impedance input for signal from 0 to 5 V
  - Current mode: Low impedance input for signal from 0 to 22 mA

- The input impedance of each pin is controlled by a bit in output memory (%Q)



When configured to current mode, analog inputs can be protected against overvoltage by using *3000AnalogInputProtection* programming library. For more information, refer to *Epec Programming and Libraries Manual*.

DI

- These pins can also be used as digital inputs by using an application library.
- The pin must be configured to voltage mode when using as digital input

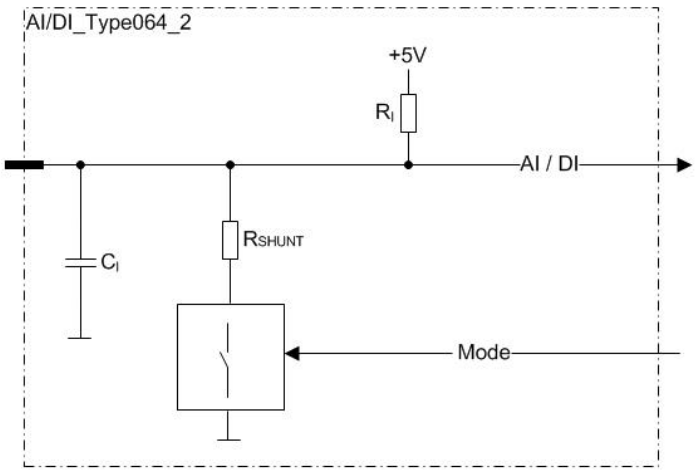
Electrical characteristics

Symbol	*Parameter*	*Conditions*	*Min*	*Max*	*Units*
V_I	Input Voltage measuring range		0	5	V
R_I	Input Resistance	Voltage mode (referenced to +5 V)	typ. 2,2 ±1%		kΩ
		Current mode	typ. 220		Ω
I_I	Input Current measuring range		0	22,7	mA
I_E	Input Error	Voltage mode		0,18	V
		Current mode		0,8	mA
BW	Input Low Pass Filter Bandwidth	-3 dB cut-off frequency	typ.40		Hz
C_I	Input pin capacitance		typ. 47		nF
$V_{I\text{-range}}$	Input voltage range	Voltage mode (Note 1)	-0,5	33	V
		Current mode (Note 1)	-0,5	30	V

Note 1: Exceeding the max value might cause damage to input.

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Functional block diagram



4.6 AI/DI_Type064_3

- These pins are analog inputs
- The pins can be configured either as a current input or as a voltage input.
- There is a control signal for selecting:
  - Voltage mode: High impedance input for signal from 0 to 5 V
  - Current mode: Low impedance input for signal from 0 to 22 mA
- Some of the inputs are divided into groups by the input impedance configuration.
  - The groups are indicated with lower case characters in the pin table's Group column in section *I/O list*).
- The input impedance of each group is controlled by a bit in output memory (%Q).

When configured to current mode, analog inputs can be protected against overvoltage by using *3000AnalogInputProtection* programming library. For more information, refer to *Epec Programming and Libraries Manual*.

DI

- These pins can also be used as digital inputs by using an application library.
- The pin must be configured to voltage mode when using as digital input

Electrical characteristics

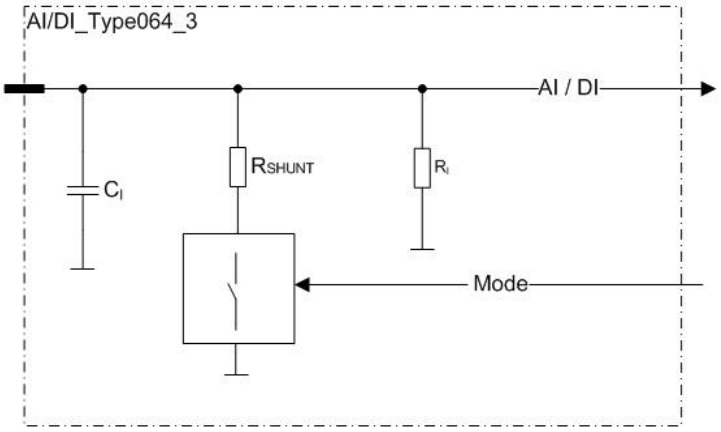
Symbol	*Parameter*	*Conditions*	*Min*	*Max*	*Units*
V_I	Input Voltage measuring range		0	5	V
R_I	Input Resistance	Voltage mode (referenced to GND)	typ. 82,0		kΩ
		Current mode	typ. 220		Ω
I_I	Input Current measuring range		0	22,7	mA

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I_E	Input Error	Voltage mode		0,18	V
		Current mode		0,8	mA
BW	Input Low Pass Filter Bandwidth	-3 dB cut-off frequency	typ. 40		Hz
C_I	Input pin capacitance		typ. 47		nF
$V_{I\text{-range}}$	Input voltage range	Voltage mode (Note 1)	-0,5	33	V
		Current mode (Note 1)	-0,5	30	V

Note 1: Exceeding the max value might cause damage to input.

Functional block diagram



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4.7 DO_GND/DI_Type048

Output (DO)

- This kind of pins are current sinking outputs.
  - In other words, pins connect the load to the ground.
- The application program can also simultaneously monitor the actual state of the pin.
  - This feature makes it possible to detect open loads and short circuits to the supply voltage.



It is recommended to use the function blocks in *DigitalOutputDiagnostics* library to protect and diagnose outputs when used as digital outputs. For more information, refer to *Epec Programming and Libraries Manual*.

Input (DI)

- A pin of this type can also be used as an input by using the output state monitoring feature.
- In those cases the output functionality of the pin must be kept in off state.
- It must be taken care in system design that the output unintentionally switching to on state causes no harm to system.

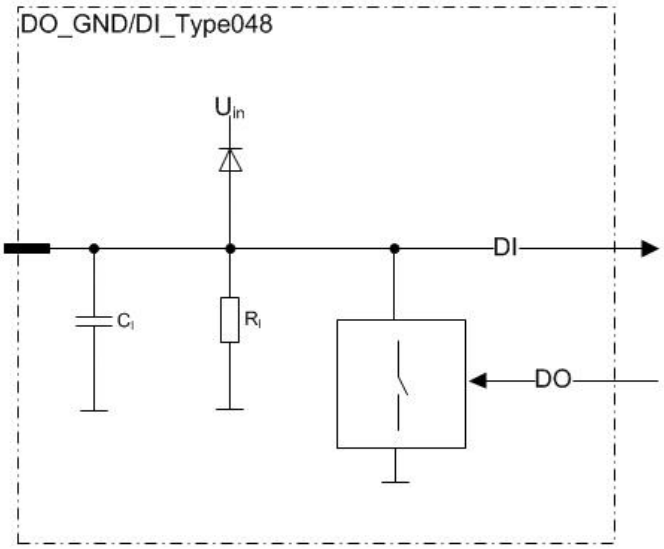
Electrical characteristics

Symbol	Parameter	Conditions	Min	Max	Units
R_O	Output Resistance	Output On		0,12	Ω
I_I	Nominal Input Current	Output On		3	A
I_L	Leakage Current	Output Off	typ. 3		mA
Digital status input					
R_I	Input Resistance	Output Off	typ. 10		kΩ
V_{IH}	Input High Voltage	Output Off	3,5	U_{in}	V
V_{IL}	Input Low Voltage	Output Off	-0,5	1,5	V
f_I	Input frequency	50% duty cycle (Note 1, 2)		1/ $2t_C$	Hz
t_I	Input Pulse Width	(Note 2, 3)	> t_C		ms
C_I	Input Pin Capacitance		typ. 1		nF

Note 1: The duty cycle is defined as the percentage of digital 'high' to digital 'low' signals present during a PWM period.
Note 2: t_C denotes the software cycle time.
Note 3: The pulse width must be greater that the software cycle time. For example with 50/50 pulse ratio, the pulse frequency is 1 / (2*pulse width)

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Functional block diagram



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4.8 DI/PI_Type046_3

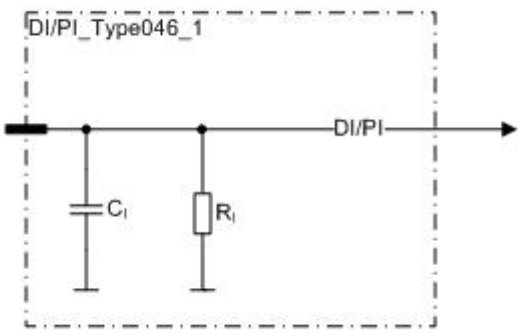
- This kind of pins are digital inputs (DI) including a pulse counting (PI) feature.
- This kind of pins have a pull-down resistor to ground
- Pulse inputs can be used as a 1 or 2 channel pulse counter and they have a reset possibility. Possible software channels and pairs are listed in Epec Programming and Libraries Manual, section *Programming 3724 > I/O > Pulse Inputs.*

Electrical characteristics

Symbol	Parameter	Conditions	Min	Max	Units
R_I	Input Resistance	Input high; Referenced to GND (Note 3)	9,5	10,5	kΩ
		Input Low; Referenced to 1,4 V	6,5	7,5	kΩ
$V_{I\text{-}level}$	Input voltage level	Unconnected pin	typ. 1,4		V
V_{IH}	Input High Voltage	Overload conditions (Note 1)	4,6	33	V
V_{IL}	Input Low Voltage		-0,5	4	V
f_I	Input Frequency (frequency measurement and pulse counting)	(Note 5, 6)		20	kHz
	Input Frequency (digital inputs)	(Note 2, 4)		$1/ 2t_C$	kHz
t_I	Input Pulse Width		1	10000	ms
C_I	Input Capacitance		typ. 1		nF

Note 1: Exceeding the max value might cause damage to input.
Note 2: t_C denotes the software cycle time in milliseconds.
Note 3: The input resistance is typically 10 kΩ, while input voltage is < 15 V. When input voltage increases over 15 V, the input resistance decreases in a non-linear function towards 6,5 kΩ.
Note 4: The pulse width must be greater that the software cycle time. For example with 50/50 pulse ratio, the pulse frequency is 1 / (2*pulse width)
Note 5: The maximum value can be reached with 50 % duty cycle.
Note 6: The maximum frequency sum for all the pins is 40 kHz.

Functional block diagram



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4.9 DI_Type046_4

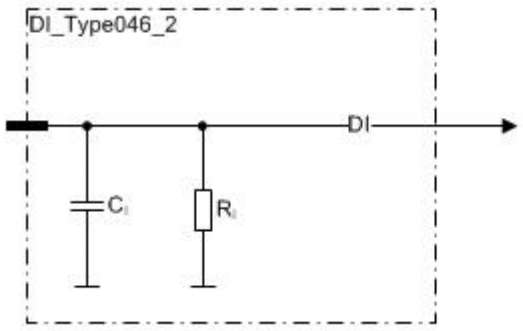
- This kind of pins are digital inputs (DI)
- This kind of pins have a pull-down resistor to ground

Electrical characteristics

Symbol	Parameter	Conditions	Min	Max	Units
R_I	Input Resistance	Input high; Referenced to GND (Note 3)	9,5	10,5	kΩ
		Input Low; Referenced to 1,4 V	6,5	7,5	kΩ
$V_{I\text{-}level}$	Input voltage level	Unconnected pin	typ. 1,4		V
V_{IH}	Input High Voltage	Overload conditions (Note 1)	4,6	33	V
V_{IL}	Input Low Voltage		-0,5	4	V
f_I	Input Frequency	(Note 2, 4)		$1/ 2t_C$	kHz
C_I	Input Capacitance		typ. 47		nF

Note 1: Exceeding the max value might cause damage to input.
Note 2: tC denotes the software cycle time in milliseconds.
Note 3: The input resistance is typically 10 kΩ, while input voltage is < 15 V. When input voltage increases over 15 V, the input resistance decreases in a non-linear function towards 6,5 kΩ.
Note 4: The pulse width must be greater that the software cycle time. For example with 50/50 pulse ratio, the pulse frequency is 1 / (2*pulse width)

Functional block diagram



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4.10 AUX OUT

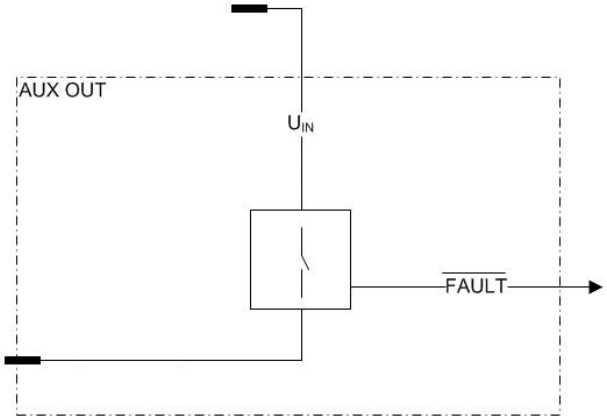
- This kind of pin is an auxiliary supply for external devices (U_{in} / max 6 A)
- The output is enabled by default during power-up
- This output has integrated protection features (overload, overcurrent)
  - In case of an error, the output is latched off and can be re-enabled only by control unit power cycle.
  - Errors are indicated with a fault signal

Electrical characteristics

Symbol	Parameter	Conditions	Min	Max	Units
R_O	Output Resistance			0,1	Ω
I_O	Output Current		0	6	A
$I_{o\text{-}lim}$	Internal current limitation	Output On (Note 1, 2)	typ. 12		A
C_O	Output Capacitance		typ. 1		nF

Note 1: Current limit for short circuit protection to protect cabling and to limit internal power dissipation.
Note 2: When the limit is exceeded, the output is latched off. The output is re-enabled only by control unit power cycle.

Functional block diagram



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4.11 +12V REF_Type70_1

- This is an internally regulated and monitored reference voltage supply for external devices.
- This reference output can be switched on/off by application.

The minimum input voltage (U_{in}) is 14 V. If the voltage is below 14 V, the given parameter values (in the table below) may not be valid.

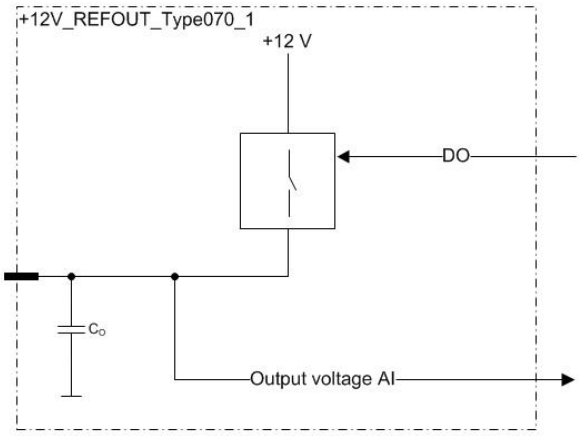
Overload protection
If the output current exceeds the nominal output current, then the output voltage is less than the specified voltage level.

Voltage monitoring
The level of the output voltage can be monitored by application.

Electrical characteristics

Symbol	*Parameter*	*Conditions*	*Min*	*Max*	*Units*
$V_{o\text{-}level}$	Output voltage	Output On, Unconnected pins	typ. 12		V
I_o	Nominal Output Current	Output On, Max total for all pins together	0	200	mA
		Output On; $T_{amb\text{-}max}$; Max total for all pins together		100	mA
C_o	Output Capacitance		typ. 10		nF
Voltage monitoring					
$V_{I\text{-}range}$	Nominal Voltage measuring range		0	23,5	V

Functional block diagram



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4.12 +5V REF_Type041_4

- This is an internally regulated and monitored reference voltage supply for external devices.
- This reference output can be switched on/off by application.

Protection features
- Overcurrent
- External voltage protection
- Errors are indicated with a fault signal

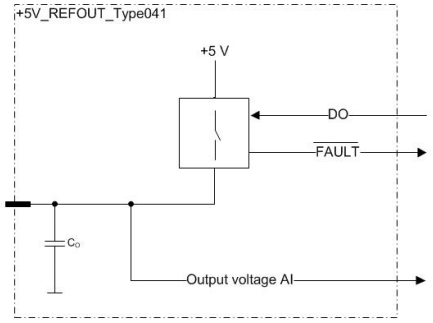
Voltage monitoring
The level of the output voltage can be monitored by application.

Electrical characteristics

Symbol	*Parameter*	*Conditions*	*Min*	*Max*	*Units*
$V_{o\text{-}level}$	Output voltage	Output On; Unconnected pins	typ. 5		V
R_o	Output Resistance	Output On		0,46	Ω
I_o	Nominal Output Current	Output On; Max total for all pins together	0	270	mA
$I_{o\text{-}lim}$	Internal Current Limitation	Output On (Note 2, 3)	typ. 370		mA
$I_{o\text{-}sc}$	Short-circuit Current Limit	Output On; Overcurrent	typ. 270		mA
C_o	Output Capacitance		typ. 4,7		uF
$V_{I\text{-}max}$	Max Input voltage	Overload conditions (Note 1)		33	V
Voltage monitoring					
$V_{I\text{-}range}$	Nominal Voltage measuring range		0	5	V
	Fault-signal overvoltage threshold	Overvoltage	Typ. 5,2		V
	Fault-signal activation time	Overvoltage / Overload		10	ms

Note 1: When output voltage is under overload conditions, for example, short circuit to supply voltages. Exceeding the max value might cause damage to output.
Note 2: Current limit for overcurrent protection to limit internal power dissipation.
Note 3: When the limit is exceeded, the output current is regulated. In regulation, the output is switched into overcurrent mode.

Functional block diagram



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Diagnostics

The +5V reference supply has two diagnostics checks:

- analog output voltage monitoring and
- dedicated digital fault-signal

Both can be used to indicate overload and overvoltage situations. The diagnostics are independent from each other.



For fastest and most reliable error detection, it is recommended to use both output voltage monitoring and fault-flag diagnostics to detect errors.

OVERLOAD

The diagnostics can detect overcurrent situation. The fault-signal is activated when excessive current is taken from the output. The output current is regulated when internal current limit is reached. The regulation current is always smaller than the limit. Current regulation causes the output voltage to drop with increasing load. This can be detected, using the output voltage monitoring feature, by setting a minimum (low) value limit for the output voltage.

With large enough loads, the output is switched temporarily off to protect the output from overheating. This is indicated by the fault-signal.
The fault-signal is deactivated, when the error source is removed by decreasing the load or when the output is turned off.



Overheat protection of the +5V REF can cause spurious errors in other analog measurements. Thus it is recommended to turn off the output when fault-signal becomes active.

OVERVOLTAGE

Overvoltage event caused by an external source can be detected by using a combination of the diagnostic features. The fault-signal is activated when pin voltage goes above the fault-signal overvoltage threshold level. If the output voltage monitoring value is 5 V (or more) and the fault-signal is active, it can be determined that an external voltage source is connected to the output pin.

The output pins are protected against external voltages, but it is not recommended to connect external voltage sources to these pins.



In case of a limit violation, the output should be disabled as soon as possible. The control unit can handle short term errors, but long term (e.g. several hours) exposures should be avoided with application/system design. Long term exposure to overvoltage or overload can cause permanent damage to the unit.

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4.13 Power Supply

- Nominal supply voltage 12/24 VDC
- Operating range 8,5…33 VDC
- Undervoltage reset ≤ 8 VDC

Overvoltage Protection

- Max. 70 V (Stresses above this value may cause permanent damage to the module.)
- Control unit has a shutdown circuit which protects the unit and loads against overvoltage. The shutdown circuit cuts off the power feed for the logic and loads in case of overvoltage. The shutdown circuit is activated when voltage reaches circa 35 V. Power feed is restored when supply voltage drops to 32,5 V.

Power Consumption

- Approx. 1,5 W (+24 VDC, no external load)
- Supply Voltage (Uin) maximum continuous current 13 A (with full external load)
- GND current sum max 13 A

Power supply pins

Designation	Connector / pin number	Potential
Supply voltage (U_{in}; for logic and power)	X4.4 X4.5	+12/+24 VDC (+8,5…33 VDC)
Ground (for supply voltage)	X4.1 X4.3	GND
Optional back-up supply * (for CPU)	X2.11	+24 VDC
Ground	X1.9 X1.10 X1.11 X2.13 X2.14 X2.15 X3.3 X3.4 X3.11 X3.12	GND (3 A/pin)
Supply outputs		
Auxiliary supply (for external devices)	X1.13	U_{in} / max 6 A
Reference supply (for external devices)	X3.1 X3.9	+12 VDC / max 200 mA (max total for all pins together)
Reference supply (for external devices)	X3.2 X3.10	+5 VDC / max 270 mA (max total for all pins together)

** This pin does not provide power supply for current sourcing outputs. Please consult manufacturer before using this pin as a unit voltage supply.*

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Always use an external fuse to protect the control unit. The fuse is needed for reverse voltage and overload protection.

Electrical characteristics

Symbol	Parameter	Conditions	Min	Max	Units
V_I	Nominal Input voltage		8,5	33	V
$I_{TOT-max}$	Max Total Current Output			13	A
$V_{I-Load-dump}$	Max Input transient Voltage level	(Note 1)		100	V
V_{I-max}	Max Continuous Input Voltage Level	(Note 2)	-0,5	40	V
V_{I-ovp}	Overvoltage Protection Cut-off Level		33	36,5	V
	Overvoltage Cut-off Hysteresis		typ. 2		V
V_{UVP}	Undervoltage Threshold Level		typ. 7,7		V
Supply voltage monitoring					
$V_{I-range}$	Nominal Input Voltage measuring range		0	46	V

Note 1: Load dump protection according to ISO7636-2: 2004 pulse 5, Us=+70V
Note 2: If the voltage is less than 8,5 V or higher than 33 V, the control unit is in non-operational state.

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5 BUS CONNECTIONS

5.1 CAN Bus

CAN interface

- Higher layer protocol is user programmable (CAN2) communication.
- The physical interface of CAN interface is according to ISO 11898 and CAN 2.0B protocol.
- The downloading of the PLCopen application can only be done via CAN1.
- All interfaces support bit rates 50, 125, 250, 500, 800, 1000 kbit/s
- CAN1 and CAN2 are CANopen compatible and user programmable
- For example CANopen, SAE J1939 or ISOBUS are available for both CANs.
- All interfaces can be configured as listen only mode. An exception is CAN1, which is in boot up normal mode because it is used for CODESYS communication.
- 11-bit and 29-bit message receive and transmit are supported.
- Transmitting of remote frames is supported in all CAN interfaces.
- Receiving one remote frame is supported. This is received for the control unit's own node guard functionality.

CAN bus connection pins

The CAN communication pins and the power supply are connected in the control unit’s AMP8 connector as follows:

Designation	Pin number
CAN1 interface, system interface, user programmable communication	X4.2 (CAN H) X4.6 (CAN L)
CAN2 interface, user programmable communication	X4.7 (CAN H) X4.8 (CAN L)
Factory use only, this pin must be left open	X3.15

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6 INTERNAL DIAGNOSTICS

6.1 Temperature and Voltage Monitoring

Type	PLCopen address	Precision	Resolution bits	Full reading
Internal Diagnostics				
AI(T_{PCB})	%IW31	≤ ± 3,5 %	10	
External Diagnostics				
AI(+5 V REF)	%IW28	≤ ± 3,5 %	10	5 V
AI(+12 V REF)	%IW29	≤ ± 3,5 %	10	23,5 V
AI(U_{in})	%IW30	≤ ± 3,5 %	10	46 V

Temperature
This control unit has one temperature sensor for monitoring PCB area temperature.
The temperature information is useful for self diagnostic purposes and safety features.

Symbol	*Parameter*	*Conditions*	*Min*	*Max*	*Units*
T_{PCB}	Nominal PCB Temperature measuring range		-40	125	°C
$T_{PCB-err}$	Temperature Measurement Error	-40 .. +125 °C		+/- 5	% (FS)

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7 APPROVALS AND SAFETY

7.1 EMC Tests

Epec 3724 control units are certified according to EMC tests that are described in this section.

The following tables provide a summary of performed EMC tests:

Emission tests according to the test specification EN 61000-6-3

Emission test	Test method
Radiated disturbance	CISPR 16-2-3
Conducted disturbance at mains ports	CISPR 16-2-1

Immunity tests according to the test specification EN 61000-6-2

Immunity test	Test method
Electrostatic discharge (ESD)	EN 61000-4-2
Radiated radio-frequency electromagnetic field	EN 61000-4-3
Electrical fast transients (EFT/B)	EN 61000-4-4
Surges	EN 61000-4-5
Conducted radio-frequency common mode	EN 61000-4-6

Emission tests according to the E/ECE Regulation No. 10, Revision 4 (2012)

Emission test	Test method	Conclusion
Measurement of radiated interference field strength in the frequency range 30 – 1000 MHz	E/ECE Reg. No. 10, Annexes 7 and 8	Pass [1)]
Measurement of conducted disturbances	E/ECE Reg. No. 10, Annex 10	Pass [2)]

[1)] Limit values according to the E/ECE Regulation No. 10, Sections 6.5.2 and 6.6.2.

[2)] Limit values according to the E/ECE Regulation No. 10, section 6.9.1.

Immunity tests according to the E/ECE Regulation No. 10, Revision 4 (2012)

Immunity test	Test method	Conclusion
Radiated radio-frequency electromagnetic field	E/ECE Reg. No. 10, Annex 9	Pass [1)]
Immunity to transient disturbances conducted along supply lines	E/ECE Reg. No. 10, Annex 10	Pass [2)]

[1)] The requirements defined in the E/ECE Regulation No. 10, section 6.10

[2)] The requirements defined in the E/ECE Regulation No. 10, section 6.8.1.

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The following tables provide more detailed descriptions about the performed EMC tests:

<table>
<tr><th colspan="2">Emission tests according to the E/ECE Regulation No. 10, Revision 4 (2012)</th></tr>
<tr><td>Radiated disturbance emission test</td><td>• Test method E/ECE Reg. No. 10, Annexes 7 and 8, CISPR 25
<table><tr><th>Frequency (MHz)</th><th>Limit value (dBmV/m)</th></tr><tr><td>30 – 1000</td><td>62/52/63
(Broadband QP)</td></tr><tr><td>30 – 1000</td><td>52/42/53
(Narrowband AVE)</td></tr></table></td></tr>
<tr><td>Conducted disturbances emission test</td><td>• Test method E/ECE Reg. No. 10, Annex 10, ISO 7637-2: 2004
<table><tr><th>Port</th><th>Limit level (V)</th></tr><tr><td rowspan="2">12V DC input</td><td>+75</td></tr><tr><td>-100</td></tr><tr><td rowspan="2">24V DC input</td><td>+150</td></tr><tr><td>- 450</td></tr></table></td></tr>
<tr><th colspan="2">Immunity tests according to the E/ECE Regulation No. 10, Revision 4 (2012)</th></tr>
</table>

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Immunity to transient disturbances conducted along supply lines test

- Test method E/ECE Reg. No. 10, Annex 10, ISO 7637-2: 2004
- Performance criterion:

Pulse	Criterion
1	C
2a	A
2b	C
3a	A
3b	A
4	C (12 V) A (24 V)
5	C

- 12 V input, Pulse:

Pulse	Pulse parameters
1	2,5 s, -150 V, R_i 10 Ω, 5000 pulses
2a	200 ms, +112 V, R_i 2 Ω, 5000 pulses
2b	500 ms, +10 V,10 pulses
3a	10/90 ms, -220 V, 60 minutes
3b	10/90 ms, +150 V, 60 minutes
4	t_d 40 ms -7 V, 20 s -6 V, 10 pulses
5	t_d 400 ms, R_i 0,5 Ω, +70 V, 1 pulse

- 24 V input, Pulse:

Pulse	Pulse parameters
1	2,5 s, -600 V, R_i 50 Ω, 5000 pulses
2a	200 ms, +112 V, R_i 2 Ω, 5000 pulses
2b	500 ms, +20 V,10 pulses
3a	10/90 ms, -300 V, 60 minutes
3b	10/90 ms, +300 V, 60 minutes
4	t_d 100 ms -12 V, 10 s -5 V, 1 pulse
5	t_d 350ms, R_i 1 Ω, +70 V 1 pulse

Immunity of ESAs to electromagnetic radiation

- Test method E/ECE Reg. No. 10, Annex 9, ISO 11452-2
- Performance criterion: No degradation of 'Immunity-related functions'
- Sweep step: 1%, time/step: 3 s

Specification	Frequency Range (MHz)	Test level
Modulation AM80% 1 kHz	20-800	30 V/m (constant peak)
PM 577/4600 µs	800-2000	30 V/m (constant peak)

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Classification of functional status *Class A:* All functions of a device/system perform as designed during and after exposure to disturbance. *Class B:* All functions of a device/system perform as designed during and after exposure to disturbance. However, one or more of them can go beyond specified tolerance. All functions return automatically to within normal limits after exposure is removed. Memory functions shall remain class A. *Class C:* One or more functions of a device/system do not perform as designed during exposure but return automatically to normal operation after exposure is removed. *Class D:* One or more functions of a device/system do not perform as designed during exposure and do not return to normal operation until exposure is removed and a device/system is reset by simple “operator/use” action. *Class E:* One or more functions of a device/system do not perform as designed during exposure and cannot be returned to operation without repairing the device/system.	

EN 61000-6-3 (2007) Electromagnetic compatibility-generic emission standard part6-3: residential, commercial and light industry	
Radiated disturbance emission test	• Test method EN 55022, CISPR 16-2-3 **Frequency (MHz)** / **Limit value (dBmV/m)** 30 – 1000 / 40/47 (QP)
Conducted disturbance at main ports emission test	• Test method EN 55022, CISPR 16-2-1 **Frequency (MHz)** / **Limit value (dBmV)** 0,15 - 30 / 66/56/60 (QP) 0,15 – 30 / 56/46/50 (AVE)
EN 61000-6-2 (2005) Electromagnetic compatibility-generic immunity standard part6-2: industrial environment	
Conducted radio-frequency common mode immunity test	• Test method EN 61000-4-6 • Performance criterion A

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<table>
<tr><td></td><td>
<table>
<tr><th>Specification</th><th>Port</th><th>Test level</th></tr>
<tr><td rowspan="2">Frequency range 0,150-80 MHz
Modulation
AM80% 1 kHz
Sweep step 1%,
time/step 3 s</td><td>DC input port</td><td>10 Vemf</td></tr>
<tr><td>Signal ports</td><td>10 Vemf</td></tr>
</table>
</td></tr>
<tr><td>Radiated radio-frequency electromagnetic field immunity test</td><td>

Test method EN 61000-4-3
Performance criterion A

<table>
<tr><th>Specification</th><th>Range (MHz)</th><th>Test level</th></tr>
<tr><td>Frequency range</td><td>80-1000</td><td>10 V/m</td></tr>
<tr><td rowspan="2">80-2700 MHz
Modulation
AM 80% 1 kHz
Sweep step 1%,
time/step 3 s</td><td rowspan="2">1000-2700</td><td rowspan="2">10 V/m</td></tr>
</table>
</td></tr>
<tr><td>Electrical fast transient (EFT/B) immunity test</td><td>

Test method EN 61000-4-4
Performance criterion B

<table>
<tr><th>Test pulse</th><th>Port</th><th>Test level</th></tr>
<tr><td rowspan="2">5 (Tr) / 50 (Th) ns, repetition frequency 5 kHz, duration 1 minute</td><td>DC input port</td><td>± 2,0 kVp</td></tr>
<tr><td>Signal port</td><td>± 1,0 kVp</td></tr>
</table>
</td></tr>
<tr><td>Surge Immunity</td><td>

Test method EN 61000-4-5
Performance criterion B (X1.13 pin is an auxiliary supply for external devices. This pin is featured with an internal latch circuit that disables auxiliary supply in case of an error (overload, overcurrent). If error occurs and output is latched off, built-in safety mechanism prevents automatic recovery. Due to this, control unit power cycle is required to re-enable the auxiliary supply pin.)

<table>
<tr><th>Specification</th><th>Port</th><th>Path</th><th>Test level</th></tr>
<tr><td rowspan="2">Pulses: 5
Repetition rate: 60 s</td><td rowspan="2">DC Input port</td><td>Line to Line</td><td>± 0,5 kVp</td></tr>
<tr><td>Line to Ground</td><td>± 1,0 kVp</td></tr>
</table>
</td></tr>
</table>

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Electrostatic discharge (ESD) immunity test	• Test method EN61000-4-2 • Performance criterion B **Discharge mode** / **Test level (kVp)** Contact: ± 2, ± 4, ± 6 Indirect contact: ± 2, ± 4, ± 6, ± 8 Air: ± 2, ± 4, ± 8

Performance criteria for immunity tests

Performance criterion A:
The EUT shall continue to operate as intended during and after the test. No degradation of performance is allowed.

Performance criterion B:
The EUT shall continue to operate as intended after the test. However, moderate degradation of performance is allowed. No change of actual operating state or loss of memory functions is allowed.

7.2 Environmental Tests

The following environmental tests have been performed to Epec 3724 control units:

Temperature			
Test	**Temperature**	**Duration/ Exposure time**	**Remarks**
Cold IEC 60068-2-1 (2007-03), Test Ad	-45 °C	16 h	• 1 °C/min
Dry heat IEC 60068-2-2 (2007-07), Test Bb	70 °C	16 h	• 1 °C/min
Damp heat cycling IEC 60068-2-30 (2005-08), Test Db	+25 °C/+55 °C		• rel. humidity >90% • cycle duration 24h • six test cycles
Change of temperature IEC 60068-2-14 (2009-01), Test Na	-50 °C/+60 °C	3 h	• change time between extreme temperatures 1-2 min • 5 test cycles
Change of temperature IEC 60068-2-14 (2009-01), Test Nb	-40 °C/+70 °C	3 h	• change of temperature 10 °C/min • 2 test cycles
Mechanical resistance			
Test	**Duration and direction**	**Remark**	

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Shock test IEC 60068-2-27 (2008-02) Test Ea	• pulse duration 6 ms • 500 impulses in six directions	• half sine pulse shape • peak acceleration 500 m/s^2
Shock test IEC 60068-2-27 (2008-02) Test Ea	• pulse duration 4 ms • 100 impulses in two directions	• half sine pulse shape • peak acceleration 750 m/s^2 and 1000 m/s^2
Vibration, random IEC 60068-2-64 (2008-04), Test Fh	• test duration 60 min in every three test direction	• ASD-level 5 m^2/s^3, 10 … 200 Hz • ASD-level 1,0 m^2/s^3, 200 … 500 Hz • total spectral acceleration 3,54 grms
Vibration, random IEC 60068-2-64 (2008-04), Test Fh	• test duration 10 min in one test direction at each level	• frequency range 10...500 Hz • ASD-level 0,1 g^2/Hz (10,0 m^2/s^3), 10...200 Hz • ASD-level 0,02 g^2/Hz (2,0 m^2/s^3), 200...500 Hz, 5,00 grms • ASD-level 0,2 g^2/Hz (20,0 m^2/s^3), 10...200 Hz • ASD-level 0,04 g^2/Hz (4,0 m^2/s^3), 200...500 Hz, 7,05 grms • ASD-level 0,4 g^2/Hz (40,0 m^2/s^3), 10...200 Hz • ASD-level 0,08 g^2/Hz (8,0 m^2/s^3), 200...500 Hz, 9,96 grms • ASD-level 0,8 g^2/Hz (80,0 m^2/s^3), 10...200 Hz • ASD-level 0,16 g^2/Hz (16,0 m^2/s^3), 200...500 Hz, 14,08 grms • ASD-level 1,45 g^2/Hz (145,0 m^2/s^3), 10...200 Hz • ASD-level 0,29 g^2/Hz (29,0 m^2/s^3), 200...500 Hz, 19,04 grms
Free fall, IEC 60068-2-31 (2008-05), Test Ec	• one fall / direction on each surface and corner	• fall height 100 cm

Corrosion

Test	Temperature	Duration	Concentration
Salt spray test ISO 9227	+35 °C	24 h	5 % NaCl

Tightness tests for IP67

Test	Duration and prosedure	Remark
Dust test for IP6X according to IEC 60529	• exposed to the free settling dust for 2 hours • underpressure during the test 1,8 kPa • flow rate of the air 0,3 l/min	• no deposit of dust noticed inside • complies with the requirements stated for the protection class IP6X

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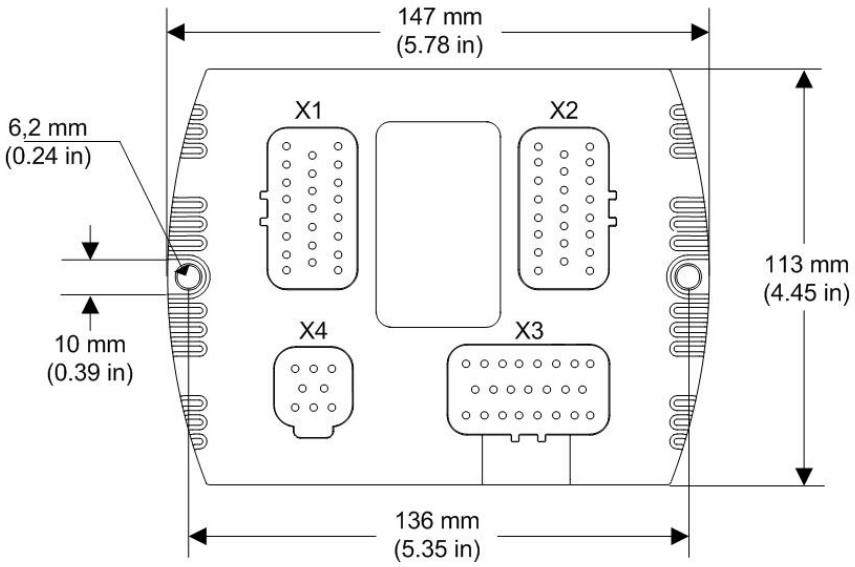
Water test for IPX7 according to IEC 60529	• immersion duration 30 minutes • immersion depth 1000 mm • water temperature +20 °C	• no ingress of water noticed inside • complies with the requirements stated for the protection class IPX7

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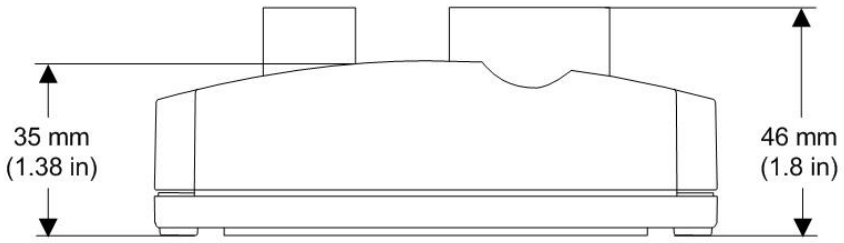
8 MECHANICS AND CABLING

8.1 Unit Dimensions

Unit dimensions from the top:



Unit dimensions from the side:



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8.2 Mounting and Cleaning

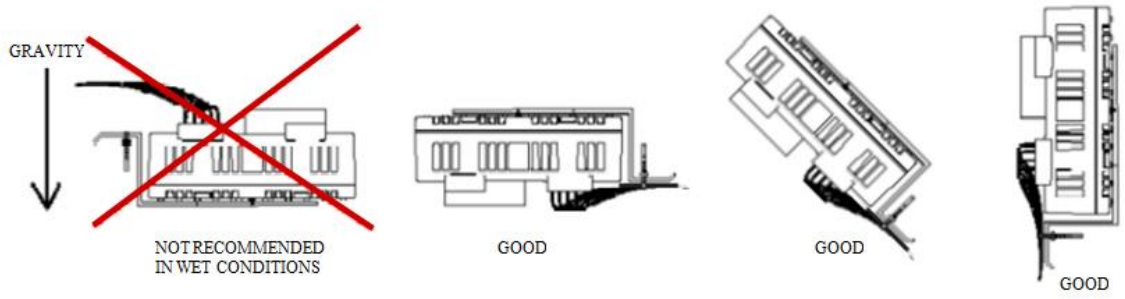
Control unit mounting location should be planned so that the machine's washing does not damage the unit.

A direct water jet towards the control units should be avoided, especially when using high pressure. Also, the use of any such solvent that causes damage to electronic devices should be avoided when handling the control units.

When cleaning the control unit, do not use highly alkaline / acidic substances, too hot water, or too heavy mechanical abrasion.

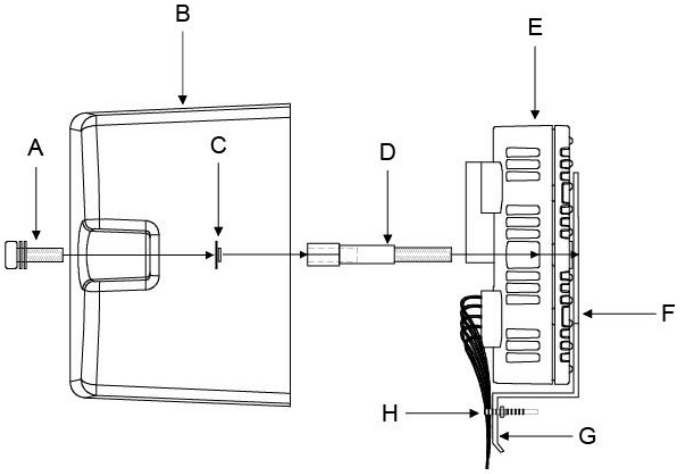
In moist conditions, the module must be mounted and oriented so that the connectors are not filled with water.

- The mounting is done with 2 screws, for example M6 according to DIN 912
- It is possible to use a spring washer under the screw head
- Mounting must be done on to a conductive metal base. The control unit's aluminum housing must have a galvanic connection to the machine frame
- The paint must be removed from the control unit under each screw head before mounting, to ensure a galvanic connection to the control unit frame. Also, remove the paint from the machine frame, where the control unit will be attached.
- Reserve 10 cm installation space for the connector cables
- Mounting position must be horizontal or vertical to allow water, etc. flowing away from connectors, see the figures below.



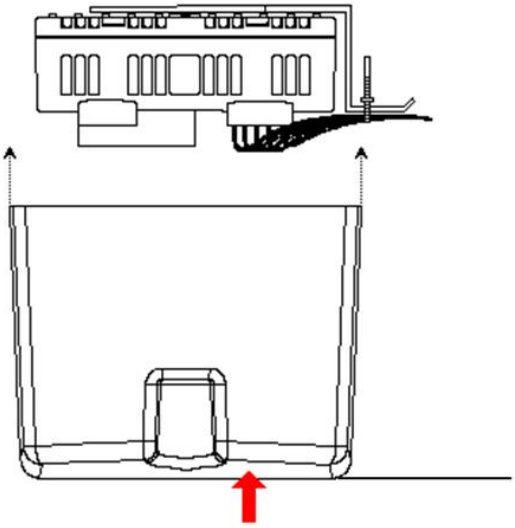
- If a separate Epec shock protection cover is mounted, it is recommended to use fastening bolts delivered by Epec.
- The following figure shows how the shock cover is mounted on top of the unit with screws (unit mounting screws have threads for unit cover screws):

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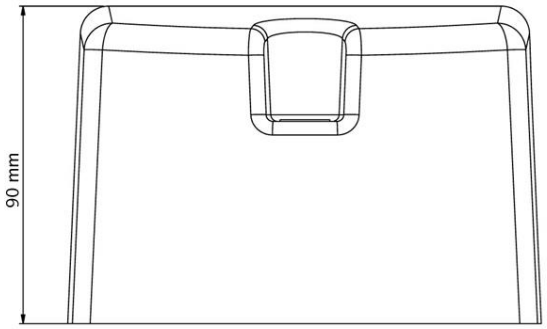
A = Shock cover mounting screw
B = Shock cover
C = Stopper washer
D = Shock cover mounting screw
E = Control unit
F = Shock cover mounting bracket
G = Shock cover base knob
H = Wires are binded to the base knob with cable ties

- If the unit is mounted upside down with a unit cover in wet conditions, it is recommended to drill a small hole on the cover to allow water flow away on the bottom of the cover. In the picture below, the red arrow points an example location of a leaking hole:

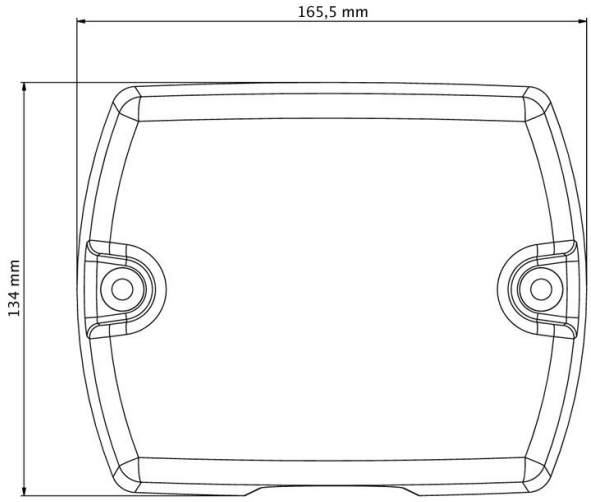


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Shock cover dimensions from the side:



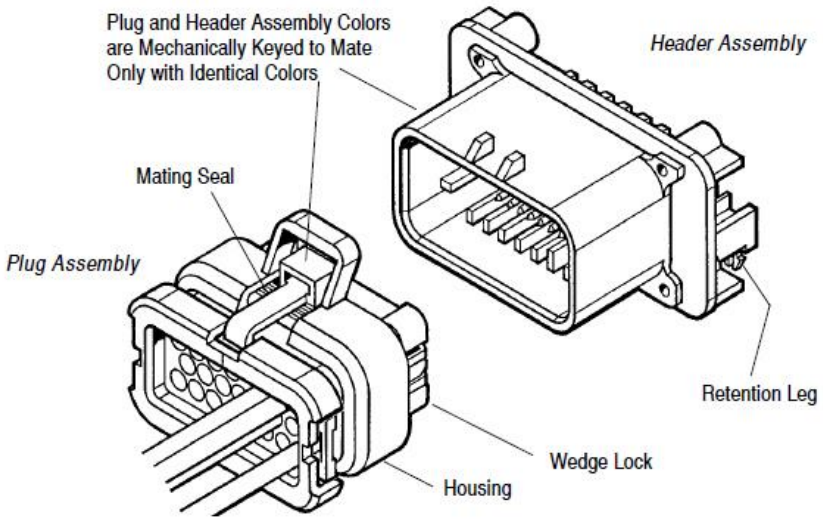
Shock cover dimensions from above:



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8.3 Plugging and unplugging the cables/connectors

All Epec control units use heavy duty gold plated, locked and sealed AMPSEAL connectors. The following figure shows an example of an AMPSEAL connector:



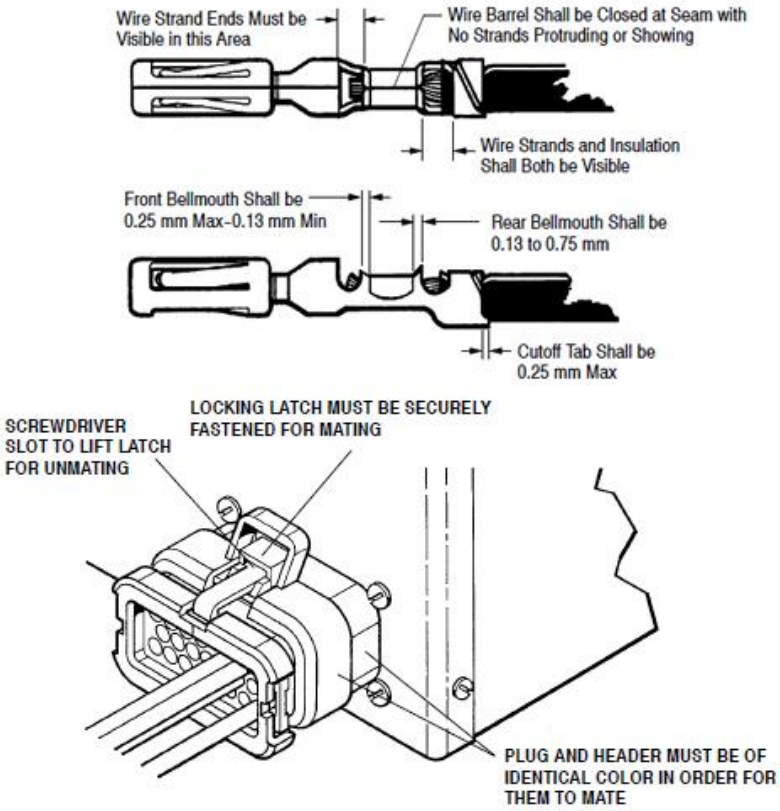
- Gold plated AMPSEAL connectors pack a current of 15 amperes per contact and tolerate operating temperature range.
- All module connectors are mechanically keyed to mate only with identical colors (blue, grey and black).

When connecting, make sure that:

- connectors are pressed down to the bottom and that they are locked
- connectors are clean (avoid moisture or dirt inside the connector)
- unused connectors are covered with empty connectors of the same color (this helps to keep the control unit connectors dry and protected)
- all cables, connectors and tools are of correct type, and sufficiently high quality, and suitable for this kind of use (protection for moisture, mechanical stability, power durability, coupling resistance among other things)
- there is a sufficient margin (slack) left in the cables to prevent the torsion of the connectors
- wires are bound to the control unit cover base knob with cable ties

The following figure describes some general instructions about the connectors.

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Refer to AMP Application Specification 114-16016 for more detailed information on connectors and cable recommendations.

Ordering codes for the AMPSEAL connectors, crimps and tools are listed in Section *Accessories*.

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8.4 Cabling

8.4.1 System Topologies



Generally, cabling should be properly designed and documented to help the initial assembly and maintenance.
It is highly recommended to mark each cable on both ends to avoid confusion and errors.



The cables must be run in a safe route along the machine frame.
When routing cables, avoid interfering objects and pay particular attention to moving parts of the machine.
It is also good to minimize the amount of the connection points of the cable harness to maximize reliability.
Also, all valid safety instructions should be observed when coupling.

- The control units are connected with each other using standardized CAN bus.
- The idea of the Epec embedded control system, is that all the control units are installed close to sensors, encoders and other equipment connected to them.
    - This way the amount of the traffic on the CAN bus is minimized and connections can be made using short wires.

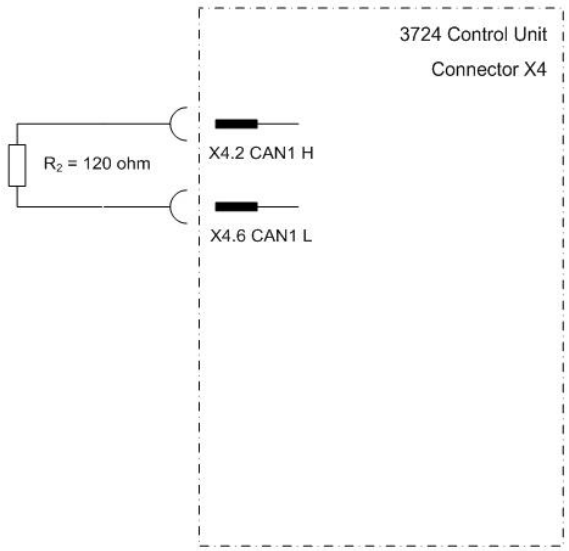
Termination resistors

- Generally, the bus cable is terminated at both ends with termination resistors (ISO 11898:1993).
    - In Epec 3724, there is an internal termination resistor (in both CANs) which can be switched on/off by software.
    - If external termination resistor (120 Ω) is used then it has to be connected at both ends between CAN H and CAN L. See the figure Example1 below.
    - When the environmental temperature exceeds 70 °C, use external termination resistor

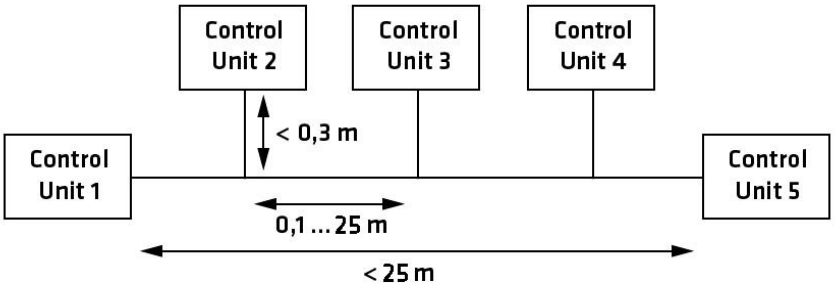


The cable lengths presented here are approximates. Actual cable lengths also depend on the cable quality, the cable type and also on the machine environment (possible interference).

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Example1. The figure shows a connection example of an external termination resistor in CAN1



Example 2. Control system topology in theory with maximum bus speed (1000 kbit/s); Control Units in traditional bus arrangement. For more information about the bus speeds, refer to CiA DS-102 standard.



Example 3. The usage of the termination resistor (TR) in a conventional bus. The maximum recommended bus length is directly dependent on the bus speed.
In theory, the maximum length with the maximum speed can be up to 25 meters. If the bus speed is lower, the length can be extended.
The maximum length of the bus depends on the bus speed. For more information about the bus speeds, see the table below / refer to CiA DS-102 standard.

The following table shows some baud rates in general purpose CAN bus networks as well as the maximum bus length for a given baud rate, that CAN in Automation (CiA) international users and manufacturers group has recommended to be used. For more information, refer to CiA DS-102 standard.

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CAN bus baud rates and bus lengths according to CiA DS-102 standard

Baudrate	Bus length
1 Mbits/s	25 m
800 kbits/s	50 m
500 kbits/s	100 m
250 kbits/s	250 m
125 kbits/s	500 m
50 kbits/s	1000 m

8.4.2 CAN Bus



The CAN bus cable is the neural backbone of the whole system and should be designed and constructed with extra care.

- The control unit's CAN1 is equipped with double pins that enables cabling without branching the wire harness
- For information about the CAN bus lengths and baud rates, refer to section *System Topologies*.

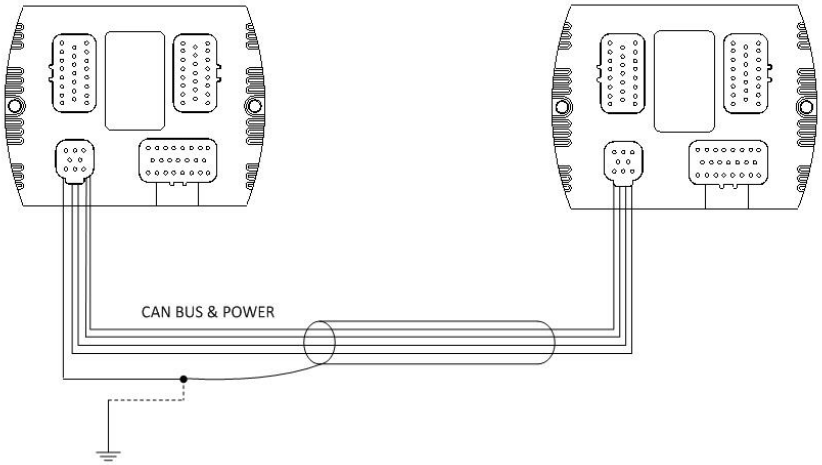
Cable

- It is recommended to use high quality and twisted (approx. 1 round/ 1 inch) CAN bus cable.
- Normal UTP (Unshielded Twisted Pairs) cable is well suited for distances under approximately 10 meters.
- In longer distances, and especially if there is possibility for electromagnetic interference, it is highly recommended to use shielded and twisted cable for CAN bus, also for shorter distances.
- To avoid electromagnetic interference (EMI), locate the bus cable as far away from high-current carrying cables as possible. Generally, the amount of the connections and connectors should be minimized to maximize security; also all connections should be done carefully.
- The shield grounding must be done only in one end of the cable

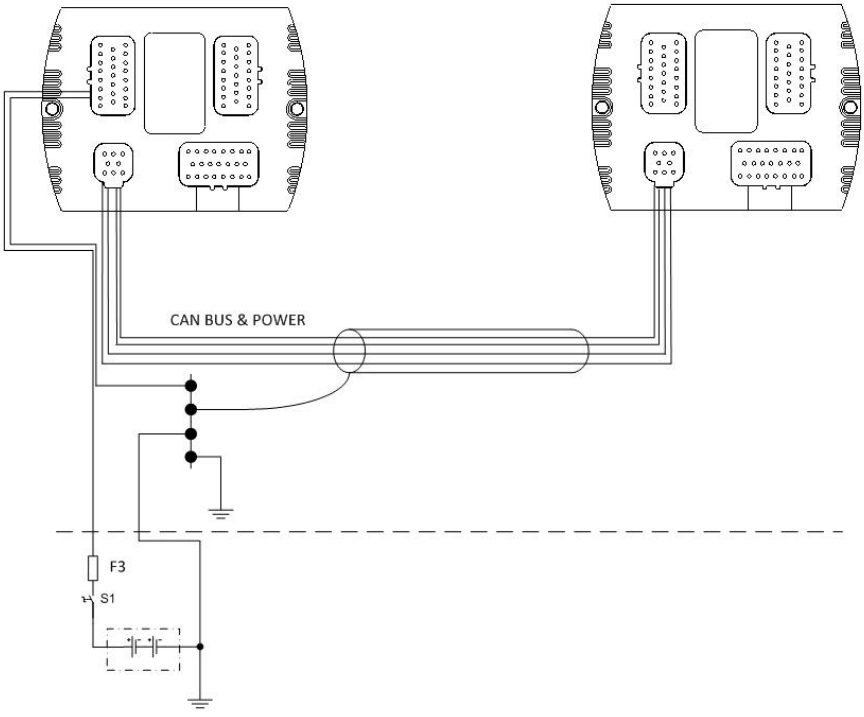
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Cable shield

Connection example when there is a GND pin available in the control unit:



Connection example when there is not a GND pin available in the control unit:



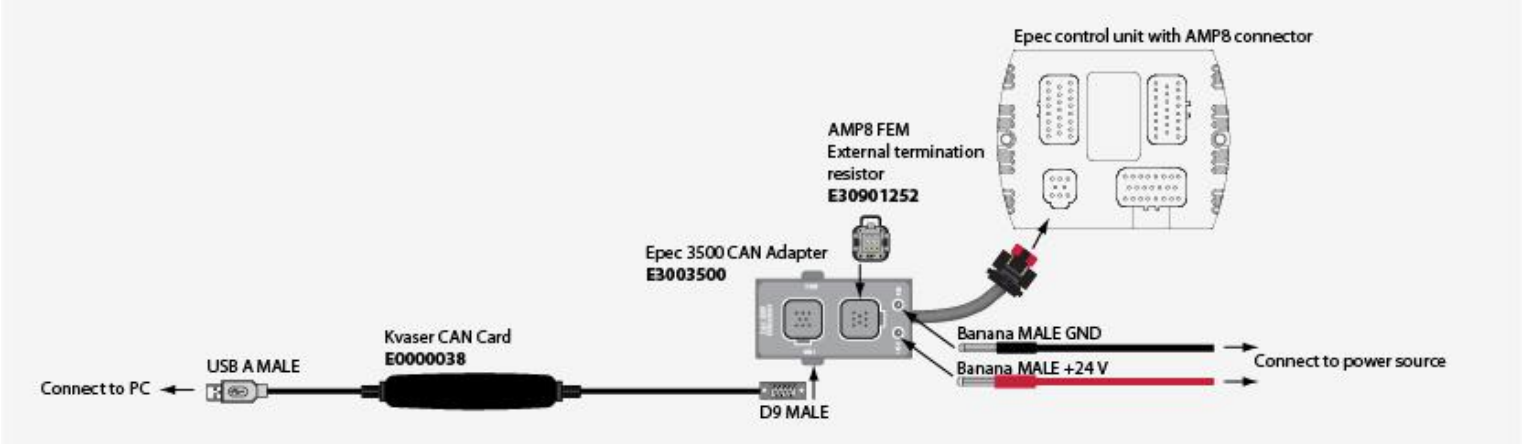
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CAN cabling for system developers

The following figure describes cabling example for CAN communication between Epec control units and PC.

Ordering codes for the needed hardware is included in the figure.

Epec control units with AMP8 connector:



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8.4.3 I/O Cabling

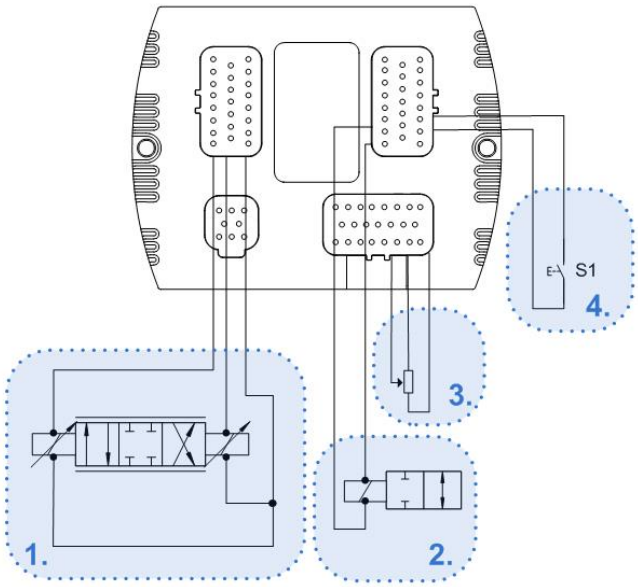
Closed circuit loops are always recommended and mandatory when you are using DO or PWM pin as an input.

Closed circuit loop means that the current from the control unit to the sensor must return to the same control unit, see the figures below.

To ensure correct measurement, reserve separate GND pin(s) for AI pin(s) and don't use it/them for any other purposes. See cabling example below.

- The cabling for encoders etc. is in many cases supplied together with them.
- In many cases, very simple basic cable may be used, e.g. automobile R2 cable (0,5 or 1,0) by NK Cables.
- Dimensions of the cable should be appropriate for AMP contacts (so that crimping is possible).
    - Refer to AMPSEAL table (in section *Accessories*) for dimensions.
    - Take extra care for protecting the cables against physical wear and damage.
- Normally, only one wire can be connected to one AMPSEAL connector pin. However, if more than one wire has to be connected to one connector pin, it has to be connected by branch wiring.
- Some voltage inputs use relatively low voltages.
    - Consider using shielded cables for these encoders etc. especially for longer distances to increase safety
- Using shielded cable is recommended also in joystick connections.

The following figure describes four different ways to connect closed circuit loop through the control unit:

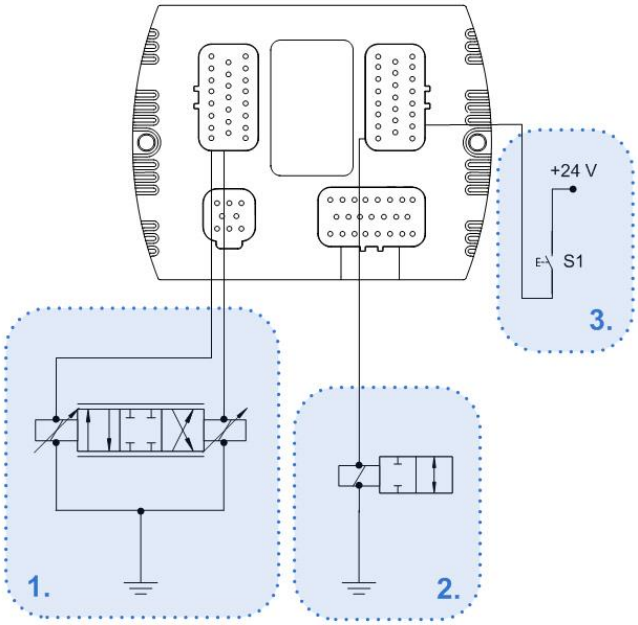


1. Proportional valve
2. ON/OFF valve

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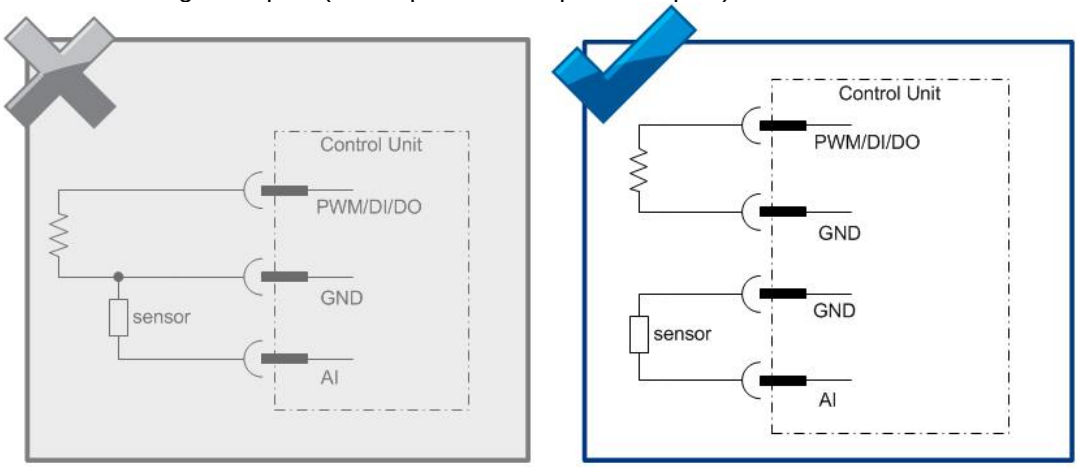
3. Joystick
4. ON/OFF switch

The following figure describes three different ways to connect open circuit loop (from the control unit's point of view):



1. Proportional valve
2. ON/OFF valve
3. ON/OFF switch

AI - GND cabling examples (use separate GND pin for AI pins):



- All sensors and encoders must be wired according to the closed-loop principle, i.e. the power for the sensors and encoders is supplied by the control unit they are connected to. This way, it is possible to avoid potential harmful differences, so the MOSFET driven output power switching operates properly.

When designing the sensor and encoder connections, observe single-point grounding. Each control unit connector has several GND pins which should be used.
Refer to section *Power supply* for accurate pin allocation of connectors.

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8.4.4 Power Supply Cabling

The maximum continuous current per pin is 10 A.

The maximum fuse that can be used per pin is 10 A.
The fuse serves as short-circuit protection.

The power for sensors, encoders and other equipment should be supplied from the very same unit that the equipment is connected to, to ensure the best performance of the system. No external power (or ground) connections are allowed.

- See section *Power Supply* for accurate pin allocation of the connectors when using Epec 3724 control unit.
- Single point grounding should be used for power supply for all control units.
- Epec recommends using doubled power cabling, though in the picture below both power cables are doubled. By using double cables one gets more area for power cables and therefore more current handling capabilities.

Generally the required area of the power cable (Cu) can be determined in following way:
Area = Max Current (A) x Nominal Resistance (Ωm) x Cable Length (m) / Max Voltage Drop (V)

Epec recommends the maximum voltage drop measured against ground potential to be at maximum 2 volts. For extra safety 1 volt should be used as a limit.

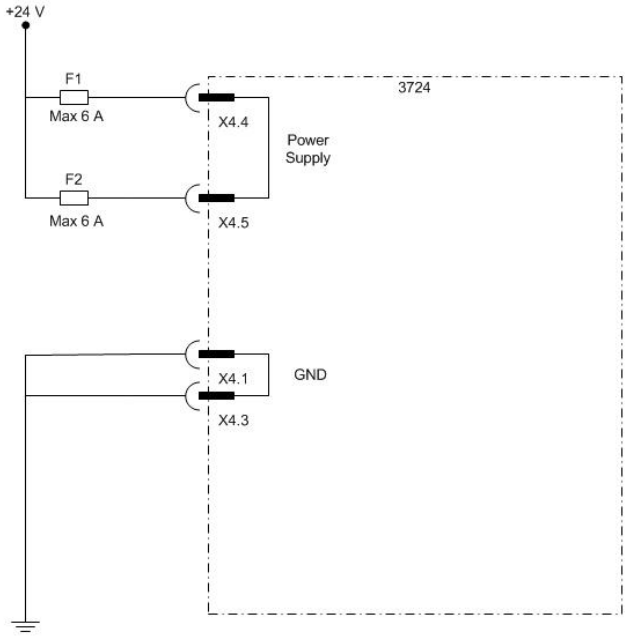
Example:
Let's assume that the machine has a 15 meters boom cable made of copper. There will be estimated 5 amps current, so the recommended cable area would be:
5 A x 0,0172*10-6 Ωm x 15 m / 2 V = 0,7 mm^2

Especially in those cases, where the formula above gives greater cable dimensions that can be fitted in AMPSEAL contacts, it is recommended to use doubled power cabling.

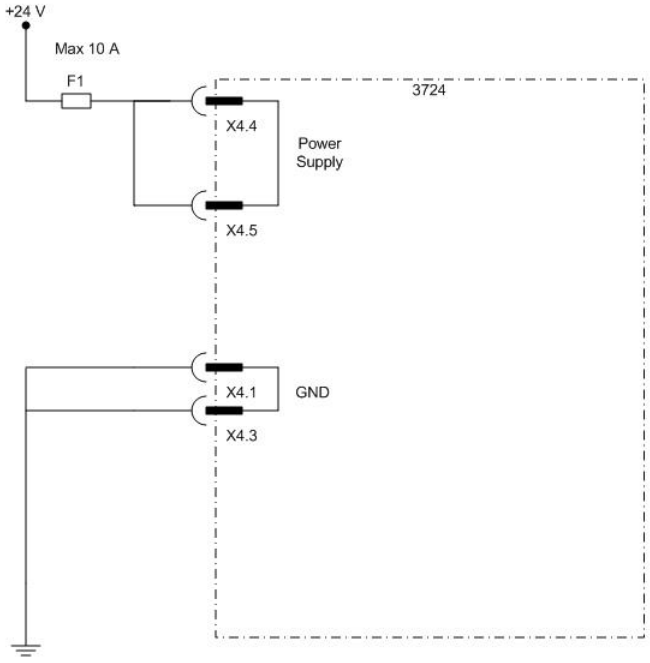
If power cables are inside the same cable with CAN bus cables, the maintenance of the system is generally easier.

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Power supply's wiring example when max 13 A is needed:

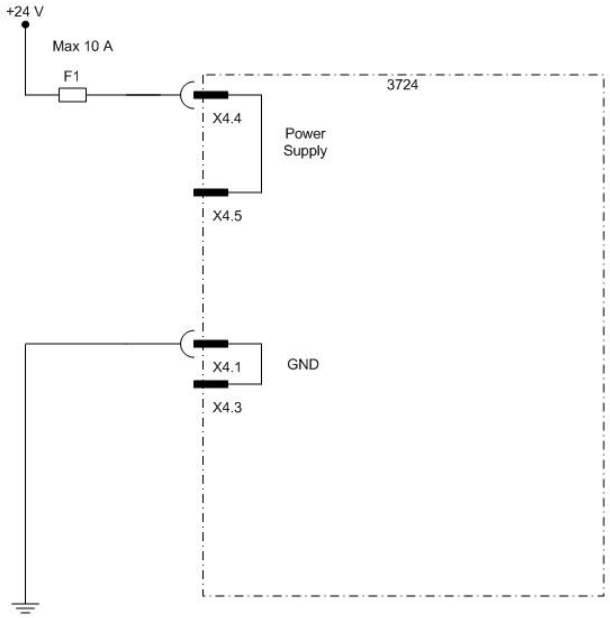


Power supply's wiring example when max 10 A is needed:

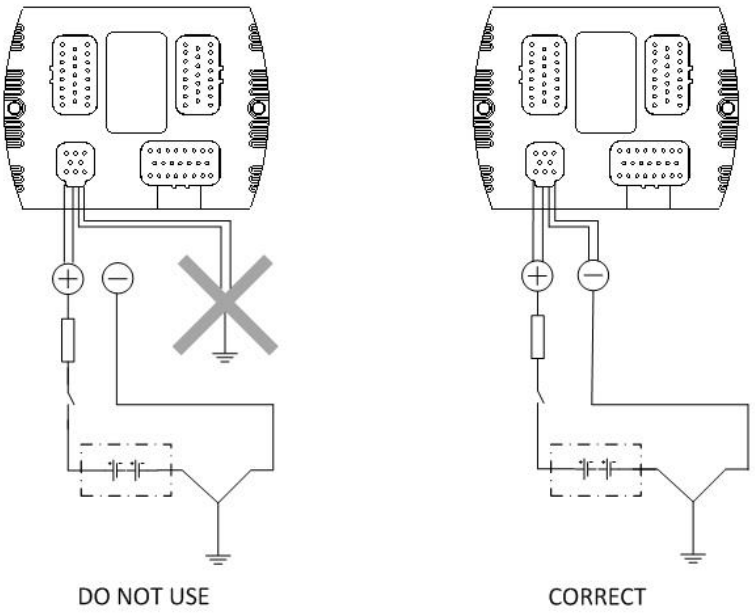


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Power supply's wiring example when max 10 A is needed:



- The power for other unit is supplied through the black AMP8 connector.
- The following figure shows a wiring example of the power supply. Single point grounding should be used for power supply for all units:



8.4.5 Emergency Stop

In all European Community countries, the emergency stop should be implemented in accordance with standard EN ISO 13850, which complies to the EC Machinery directive 2006/42/EC. In other countries, the emergency stop should be implemented according to local standards and/or to local legislation.

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8.5 Welding



Welding causes some high current flows and voltage peaks in the machine. It should be noted that the electronics of the control system may be damaged, if the welding current can get through the control unit itself.
So, when welding, it should be taken care to prevent high currents from going through the control units or through the CAN bus.

Follow carefully the following instructions.



Disconnect all the connectors from the control units before welding.



Generally, even if the control system power is disconnected, welding should be done carefully and by following appropriate safety measures. Welding grounding should be connected close to the welding point to avoid long distance high current flow through machine frame.

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8.6 System Examples

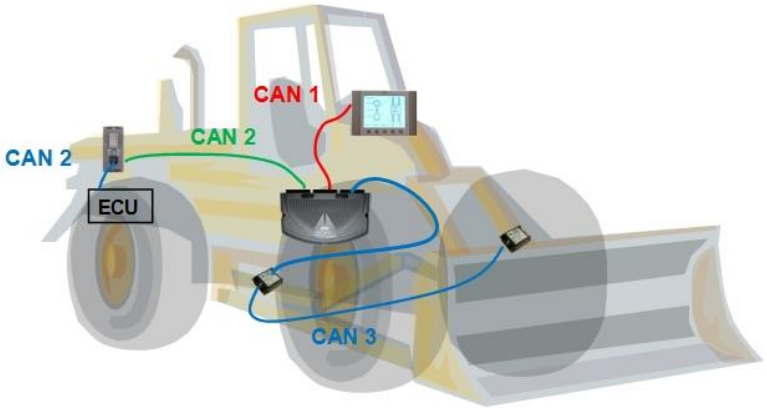
Loading machine

Cabin control unit
- reads the joysticks and switches
- controls the boom and bucket
- controls the gearing
- controls the steering and brakes
- controls the lights

Rear frame control unit
- controls the engine
- controls the hydraulic pumps
- controls the rear lights

Tilt sensors
- measures the frame position
- measures the loader position

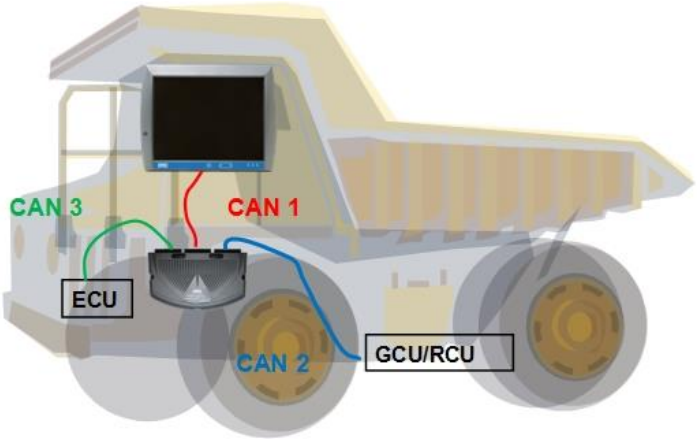
Display
- gauge
- diagnostics
- software updating



Dumper

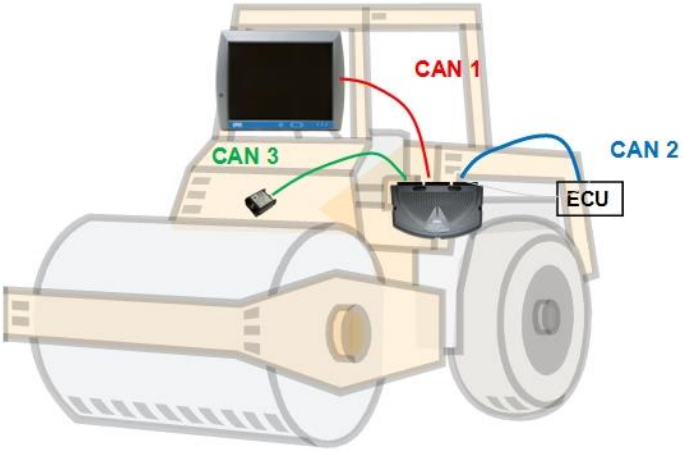
Cabin control unit
- reads the joysticks and switches
- controls the engine
- controls the gearing
- controls the driveshaft brake
- controls the steering and brakes
- controls the dump box

Display
- remote connection
- positioning
- gauge
- diagnostics
- software updating



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Landfill compactor

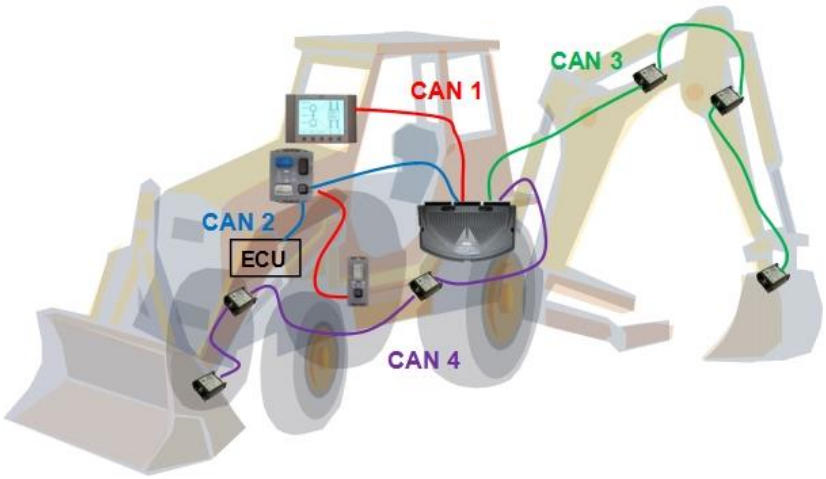


Cabin control unit
- reads the joysticks and switches
- controls the engine
- controls the transmission
- controls the steering
- controls the lights

Tamping sensors
- measures the degree of concentration

Display
- remote connection
- positioning
- gauge
- diagnostics
- software updating

Backhoe



Cabin control unit
- reads the joysticks and switches
- controls the excavator
- controls the roof lights
- booms' position calculation

Engine control unit
- controls the engine
- controls the front loader
- reads the fluid pressures and temperatures

Gearing control unit
- controls the gearing
- controls the suspension

Tilt sensors
- measures the frame position
- measures the excavator and front loader positions

Display
- gauge
- diagnostics
- software updating

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8.7 Accessories and Ordering Codes

Related products

Picture	Product Name	Epec ordering code	Epec data sheet code
	Shock Cover for Epec Control Units	E30C02192	MAN000401
	Epec Simulator Box for Control Unit 2024	E3003503	MAN000411
	3500 CAN Adapter Box	E3003500	MAN000385
-	External termination resistor	E30901252	-

AMPSEAL Connectors

Epec uses gold plated, locked and sealed AMPSEAL heavy duty connectors for all Epec CAN Module Family products to ensure endurance under extreme conditions.

- All connectors are mechanically keyed to mate only with identical colors

AMPSEAL product	TE Connectivity ordering code	Epec ordering code
Contact for AMP plug assembly	770854-3	KX0010
Crimping tool	58529-1	TT0018
AMP 23-pin Plug Assembly, Grey	770680-4	KX0007
AMP 23-pin Plug Assembly, Grey with 2 m leads	-	E30901310
AMP 23-pin Plug Assembly, Black	770680-1	KX0008
AMP 23-pin Plug Assembly, Black with 2 m leads	-	E30901311
AMP 23-pin Plug Assembly, Blue	770680-5	KX0009
AMP 23-pin Plug Assembly, Blue with 2 m leads	-	E30901312
AMP 8-pin Plug Assembly, Black	776286-1	KX0187
AMP 8-pin Plug Assembly, Black with 2 m leads	-	E30901313

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AMPSEAL cable dimensions

Size		Insulation diameter range	Strip length ±0,4
mm²	AWG		
0,5	20	1,7 to 2,7	5,1
0,8	18		
1,4	16		
1,5	---	2,2 to 2,4	

Typical hand crimping tool e.g.: AMP Procrimper 58529-1 (TE Connectivity), Epec ordering code TT0018

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